



TRANSLATOR'S DECLARATION

I, CHRISTA SCHAERTEL, declare and say:

1. That I reside at 413 South Fayette Street, Alexandria, Virginia 22314;

2. That I am thoroughly familiar with the German, French and English languages, holding Translator's and Interpreter's Diplomas from the Institute of Interpreting and Foreign Languages, Goettingen, Germany, and the Chamber of Industry and Commerce of Wiesbaden, Germany;

3. That I translated the *German Patent Application 10110 702.1* with the title  
*LASER WELDING OF NONFERROUS METALS BY USING LASER  
DIODES AND PROCESS GAS,*

written in the German language; and

That the attached is a correct English translation of the above-mentioned German-language document to the best of my knowledge and belief.

*Christa Schaertel*

Christa Schaertel

Date: 11/28/06



**FEDERAL REPUBLIC OF GERMANY**

**Priority Certificate  
Concerning  
The Filing of a Patent Application**

File Number: 101 10 702.1  
Filing Date: March 6, 2001  
Applicant/Holder: LINDE AKTIENGESELLSCHAFT  
Wiesbaden/DE  
First Applicant: Linde Gas AG,  
Höllriegelskreuth/DE  
Title: Laser Welding of Nonferrous  
Metals by Using Laser Diodes and  
Process Gas  
IPC: B 23 K, B 01 J

**The attached items are a correct and precise copy of  
the original documents of this patent application.**

(Seal)

München, October 23, 2003  
German Patent and Trademark Office  
The President  
By Order  
(Signature)  
Wehner



P01042-DE/GTG = EM-GTG0815a

March 6, 2001 - Obermüller

### Specification

## LASER WELDING OF NONFERROUS METALS BY USING LASER DIODES AND PROCESS GAS

The invention relates to a process gas for use during laser welding of nonferrous metallic workpieces by means of a laser beam focused onto the workpiece to be welded, a laser diode being used as a laser beam source.

The invention also relates to a process for the laser welding of nonferrous metals, in which case a laser diode or several laser diodes are used as the laser beam source, at least one focused laser beam being guided to a workpiece surface to be machined, and a process gas flow being guided against the workpiece surface.

The characteristics of laser radiation, particularly the intensity and the good focusing capability, have had the result that nowadays lasers are used in many material machining fields. Laser machining systems are often used in connection with computerized numerical controls (CNC). Corresponding laser

machining systems are known in numerous variations.

Within the scope of the invention, a focused laser beam is a laser beam which is essentially focused on the workpiece surface.

In addition to the predominantly used method with the laser radiation focused on the workpiece surface, the invention can also be used in the case of the seldom used variant in which the radiation is not focused exactly onto the workpiece surface.

In many methods of laser material machining, metallic and/or other material is heated to temperatures at which a reaction takes place with the enveloping gases. In many cases, industrial gases are therefore used in order to be able to carry out these material machining processes more effectively, faster and/or with an improved quality.

With respect to laser welding, it is known to use inert protective gases, such as helium or argon. Nitrogen is also sometimes used. In some cases, additions of active gas fractions, such as carbon dioxide, oxygen or hydrogen are also admixed to argon or nitrogen.

The tasks of the process gases during laser welding are multiple. The process gases determine, among other things, to a large extent, the economic efficiency, the quality and the

process reliability of the laser welding.

Diode lasers as a laser beam source, in comparison to solid-state lasers (for example, Nd:YAG-lasers) and gas lasers (for example, CO<sub>2</sub> lasers) are of interest during laser welding because of a number of advantages: Diode lasers represent an extremely efficient artificial light source. They can be installed without great expenditures and, as a rule, can sufficiently operate with a conventional power supply as the energy supply. They are small and very compact. Further, they have a high efficiency (with 40 to 50% approximately five times higher than in the case of a conventional laser system). Finally, they have a long lifetime (normally at least 10,000 hours).

So far, diode lasers have not been successful in practice for laser welding of nonferrous metals. Insufficient laser welds occurred, particularly with low welding depths.

From our own published German Patent Document DE 199 01 900 A 1, it is known to use a process gas for the laser welding of low-alloy steel types and zinc-coated steel types which contains, in addition to helium and possibly argon, at least carbon dioxide with a fraction of up to 40 % by volume. The laser welding of nonferrous metals is not considered in detail in German Patent Document DE 199 01 900 A1.

Specifically during the laser welding of nonferrous metals, because of reflections of the radiation on the workpiece surface, frequently only a low coupling-in of energy takes place which, as a rule, does not permit a qualitatively high laser welding process using laser diodes as the laser beam source.

It is therefore an object of the invention to indicate a process gas and a process of the initially mentioned type which permit an improved laser welding of nonferrous metals by means of laser diodes. A high-quality laser welding process was to be provided. In particular, by means of the process gas, in addition to controlling and reducing the plasma, a laser weld was to be achieved at a high welding speed, with a deep penetration, of a high quality and with good seam geometries.

According to the invention, this object is achieved in that the process gas contains at least carbon dioxide.

Within the scope of the invention, in contrast to ferrous metals and types of steel, nonferrous metals are particularly aluminum materials and alloys, magnesium materials and alloys, nickel base materials and alloys, copper materials and alloys and/or brass-containing materials.

It is decisive for the invention that surprisingly carbon dioxide in the process gas results in an extremely good coupling-in of energy. This is possibly based on the dipole character of the carbon dioxide molecule in the process gas. Presumably, because of the carbon dioxide from the process gas, vibrations are generated in the workpiece, which lead to the desired result of a high-quality laser welding process. Whether here a conversion of the radiation energy to rotation and/or vibration energy is finally responsible for this improvement could not yet be conclusively clarified at this time. At any rate, laser welding processes without any local overheating can surprisingly be carried out by means of the invention.

As an embodiment of the invention, the process gas contains between 10 and 100% by volume carbon dioxide. This information relates to wanted constituents of the process gas and not to unwanted or production-caused impurities. The carbon dioxide may therefore also contain normal impurities in the case of a fraction of 100% by volume. Advantageously, the fraction of carbon dioxide in the process gas is at 15 and 90% by volume, preferably between 45 and 85% by volume, particularly preferably between 55 and 80% by volume.

As a further development of the invention, the process gas is fed in the direction of the normal line (at an angle of 90°)

of the workpiece surface.

In addition to carbon dioxide, the process gas can contain argon, nitrogen, helium and/or other precious gases. The process gas can advantageously also contain oxygen at a fraction of up to 50% by volume.

Particularly process gases

- of a binary gas mixture with the constituents carbon dioxide and argon,
  - of a binary gas mixture with the constituents carbon dioxide and nitrogen,
  - of a binary gas mixture with the constituents carbon dioxide and oxygen,
  - of a ternary gas mixture with the constituents carbon dioxide, argon and helium,
  - of a ternary gas mixture with the constituents carbon dioxide, argon and oxygen,
- or
- of a ternary gas mixture with the constituents carbon dioxide, argon and nitrogen
- have been successful.

As an embodiment of the invention - particularly also for the above-mentioned binary and ternary gas mixtures respectively



- laser diodes with a wavelength of from 700 to 1,300 nm, preferably of from 800 to 1,000 nm, are suitable for the laser welding. Thus, high-power laser diodes in the infrared range are preferred for the invention.

Within the scope of the invention, particularly high-power laser diodes with a laser power of from 0.5 to 6 kW, preferably between 1 and 4 kW, can be used.

The invention as well as further details of the invention will be explained in detail in the following by means of test results shown in the figures.

Figure 1 is a micrograph of a workpiece after a laser welding using argon;

Figure 2 is a micrograph of a workpiece after a laser welding according to the invention using carbon dioxide.

The micrograph of Figure 1 shows a workpiece made of AlMgSi1 of a thickness of 2 mm, which was welded by means of a laser diode of a 3 KW laser power according to the prior art using a process gas of argon fed concentrically to the laser beam at 90° onto the workpiece surface at a welding speed of 1 m/min.

In comparison to the above, the micrograph of Figure 2 shows an identical workpiece made of AlMgSi1 of a thickness of 2 mm which was welded according to the invention also by means of a laser diode of a 3 KW laser power using a process gas of carbon dioxide fed concentrically to the laser beam at 90° onto the workpiece surface at a welding speed of 1 m/min.

In comparison to the welding according to Figure 1 using argon, the advantages of the invention are clearly apparent in Figure 2, specifically that the coupling of energy into the workpiece to be welded could be increased significantly by means of the carbon dioxide process gas while otherwise the conditions were the same. Thus, the welded surface present in the sectional view, in the case of Figure 1, has a value of  $0.93 \text{ mm}^2$ , while, in the sectional view according to Figure 2, a surface of  $5.75 \text{ mm}^2$  is obtained. The effect during the laser welding could therefore be increased approximately six times only by changing the process gas from argon to carbon dioxide.

P01042-DE/GTG = EM-GTG0815a

March 6, 2001 - Obermüller

CLAIMS:

1. Process gas for use during laser welding of nonferrous metallic workpieces with a laser beam focused onto the workpiece to be welded, a laser diode being used as a laser beam source, characterized in that the process gas contains at least carbon dioxide.

2. Process gas according to Claim 1, characterized in that the process gas contains between 10 and 100% by volume carbon dioxide.

3. Process gas according to Claim 1 or 2, characterized in that the process gas contains between 15 and 90% by volume carbon dioxide, preferably between 45 and 85% by volume carbon dioxide, particularly preferably between 55 and 80% by volume carbon dioxide.

4. Process gas according to one of Claims 1 to 3, characterized in that the process gas is fed in the direction of the normal line (at an angle of 90°) to the workpiece surface.

5. Process gas according to one of Claims 1 to 4, characterized in that, in addition to carbon dioxide, the process gas contains argon, nitrogen, helium and/or other precious gases.

6. Process gas according to Claims 1 to 5, characterized in that, in addition to at least carbon dioxide, the process gas contains oxygen of a fraction of up to 50% by volume.

7. Process gas according to one of Claims 1 to 6, characterized in that the process gas consists of a

- of a binary gas mixture with the constituents carbon dioxide and argon,

- of a binary gas mixture with the constituents carbon dioxide and nitrogen,

- of a binary gas mixture with the constituents carbon dioxide and oxygen,

- of a ternary gas mixture with the constituents carbon dioxide, argon and helium,

- of a ternary gas mixture with the constituents carbon dioxide, argon and oxygen,

or

- of a ternary gas mixture with the constituents carbon dioxide, argon and nitrogen.

8. Process for the laser welding of nonferrous metals, a laser diode or several laser diodes being used as the laser beam source, at least one focused laser beam being guided to a workpiece surface to be machined, and a process gas flow being guided against the workpiece surface, characterized in that a process gas according to one of Claims 1 to 7 is used.

9. Process according to Claim 8, characterized in that laser diodes of a wavelength of from 700 to 1,300 nm, preferably of from 800 to 100 (1,000 ? translator) nm, are used.

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ABSTRACT:

LASER WELDING OF NONFERROUS METALS BY USING LASER DIODES AND  
PROCESS GAS

The invention relates to a process gas for use during laser welding of nonferrous metallic workpieces with a laser beam focused onto the workpiece to be welded, a laser diode being used as a laser beam source. According to the invention, the process gas contains at least carbon dioxide. The process gas can have between 10 and 100 % by volume carbon dioxide. In addition to carbon dioxide, the process gas can also contain argon, nitrogen, helium and/or other precious gases, as well as oxygen of a fraction of up to 50% by volume.

Translation of Figure 1:

Schliff            micrograph

Mittig            center